PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference E1043.WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/GB2004/003566	International filing date *(day/month/year)* 19.08.2004	Priority date *(day/month/year)* 19.08.2003
International Patent Classification (IPC) or national classification and IPC H04B5/00, G01S11/06		
Applicant PLEXTEK LIMITED et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 7 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 9 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the opinion
   - ☐ Box No. II Priority
   - ☒ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☒ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☐ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
11.03.2005	08.11.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Lopez Marquez, T Telephone No. +31 70 340-4087

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/003566

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1, 2, 4-20	as originally filed
3, 3a	received on 15.06.2005 with letter of 13.06.2005
Claims, Numbers	
1-35	received on 15.06.2005 with letter of 13.06.2005
Drawings, Sheets	
1/8-8/8	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/003566

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos. 24-35

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for the said claims Nos. 24-35

☐ the nucleotide and/or amino acid sequence listing does not comply with the standard provided for in Annex C of the Administrative Instructions in that:

the written form	☐	has not been furnished
	☐	does not comply with the standard
the computer readable form	☐	has not been furnished
	☐	does not comply with the standard

☐ the tables related to the nucleotide and/or amino acid sequence listing, if in computer readable form only, do not comply with the technical requirements provided for in Annex C-*bis* of the Administrative Instructions.

☐ See separate sheet for further details

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/003566

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation to restrict or pay additional fees, the applicant has:
   - ☐ restricted the claims.
   - ☐ paid additional fees.
   - ☐ paid additional fees under protest.
   - ☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☐ not complied with for the following reasons:

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. 1-23 .

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-23
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-23
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-23
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: US 2002/140419 A1 (DURET DENIS) 3 October 2002 (2002-10-03)

1.1 The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document): a radio frequency receiver for use in a proximity detecting system, the radio frequency receiver comprising at least one antenna coil operable to receive radio frequency signals; a signal processor arranged to amplify and filter signals received by the radio frequency receiver; and a processing system arranged to evaluate a amplitude associated with each antenna coil, the processing system being arranged to evaluate a displacement of the receiver with respect to the transmitter on the basis of the evaluated amplitude (abstract; page 1, paragraphs 9 to 21; page 2, paragraphs 32 and 33).

1.2 The subject-matter of claim 1 differs from this known receiver in that it further comprises a tunable receiver circuitry arranged in cooperative association with the antenna coil and arranged to modify the frequency at which radio signals are received by the radio frequency receiver; the signal strength associated with each antenna coil is evaluated; the distance between the transmitter and the receiver is evaluated on the basis of the signal strengths; and the received and processed signals are of frequencies between 100kHz and 10MHz.

1.3 The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

1.4 The problem to be solved by the present invention may be regarded as providing a radio frequency receiver capable of accurately determining the distance between transmitter and receiver within 10mm. By working within the 100kHz - 10MHz range of operation, this is within the near field of the transmitter, the signal strength is proportional to the inverse cube of the distance, allowing the distance to be accurately identified.

1.5 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT).

1.6 Claims 2 to 15 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

2.1 The document D1 also shows: a frequency radio receiver for use in a proximity detecting system, the radio frequency receiver comprising antenna coils being operable to receive radio frequency signals at frequencies less than 10 MHz; a signal processor arranged to amplify and filter signals received by the radio frequency receiver (abstract; page 1, paragraphs 9 to 21; page 2, paragraphs 32 and 33).

2.2 The subject-matter of claim 16 differs from this known receiver in that it further comprises a tunable receiver circuitry arranged in cooperative association with the antenna coil and arranged to modify the frequency at which radio signals are received by the radio frequency receiver; and frequency sequence identifying means arranged to identify, within a time period, a sequence of frequencies in the amplified and filtered signals.

2.3 The subject-matter of claim 16 is therefore new (Article 33(2) PCT).

2.4 The problem to be solved by the present invention may be regarded as providing a radio frequency receiver capable of eliminating noise and interferences, which a receiver operating at such low frequencies is likely to receive in addition to the signals emanating from the transmitter. The receiver of claim 16 is configured to identify a frequency hopping pattern used by the transmitter and to process the signals received according to the identified frequency hopping pattern.

2.5 The solution to this problem proposed in claim 16 of the present application is considered as involving an inventive step (Article 33(3) PCT).

2.6 Claims 17 to 23 are dependent on claim 16 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

3. Parts of the description relating to the non searched second invention and claims 24 to 35 should be excised from the application.

strength whatsoever. Applications utilizing RSSI to identify location are described in United States patent US 5,714,932 and United States patent US 5,218,344.

US patent application US2002/140419 describes a system for measuring small changes in distance. The system comprises a fixed unit and a mobile unit, the mobile unit being a passive transponder that reflects signals broadcast by the fixed unit. The distance between the fixed and mobile units is determined by the variation of mutual coupling between the coil in the mobile unit and the coil in the fixed unit: the fixed unit broadcasts a field that is picked up by the mobile unit coil, generating a voltage in that coil that, in turn, creates a current in the coil. This current creates an opposing magnetic field that is "sensed" by the fixed unit coil with the result that its impedance changes and this impedance change is measured by the fixed unit's bridge detector circuit. The range of the system is dependent on mutual coupling between the coils and the sensitivity of the circuit to detect changes to this coupling. The further they are separated, the weaker the coupling and there will come a point where a change in distance will make a change in output voltage that is comparable with the noise level of the circuit. As described in paragraphs 1 and 9 of the application, the system can only work over very short distances, of the order few cm.

Summary of the Invention

According to a first aspect of the present invention there is provided a radio frequency receiver for use in a proximity detecting system, the radio frequency receiver comprising

at least one antenna coil operable to receive radio frequency signals;

tunable receiver circuitry arranged in operative association with the antenna coil and being arranged to modify the frequency at which radio signals are received by the radio frequency receiver;

a signal processor arranged to amplify and filter signals received by the radio frequency receiver;

a processing system arranged to receive radio signals amplified and

filtered by the signal processor so as to evaluate a signal strength associated with each said antenna coil, the processing system being arranged to evaluate a distance between a radio frequency transmitter and the radio frequency receiver on the basis of evaluated signal strengths associated with radio signals received by at least one antenna coil, wherein the radio frequency receiver is operable to receive and process radio signals of frequencies between 100kHz and 10MHz.

An advantage of operating in this low frequency range is that multi-path problems associated with high frequency systems, such as reflections from objects located between the path of the transmitter and receiver, are significantly reduced. A further advantage is that emissions from a low frequency transmitter remain as a near field transmission for distances of tens or even hundreds of metres from the transmitter (the extent of the near field depending on operating frequency). When operating within the near field of a transmitter, signal strength is proportional to the inverse cube of distance from it, allowing its range to be identified extremely accurately. In some circumstances (i.e. for some operating frequencies), this distance can be identified to within ±10 mm. Within the 100 kHz – 10 MHz range of operation, radio signals from loop antennas emanate primarily as a magnetic field, which, being a vector, has a direction in addition to a magnitude. The direction of the magnetic field varies in a non-uniform way, which means that, in order to measure the magnitude of

Claims

1. A radio frequency receiver for use in a proximity detecting system, the radio frequency receiver comprising

at least one antenna coil operable to receive radio frequency signals;

tunable receiver circuitry arranged in operative association with the antenna coil and being arranged to modify the frequency at which radio signals are received by the radio frequency receiver;

a signal processor arranged to amplify and filter signals received by the radio frequency receiver; and

a processing system arranged to receive radio signals amplified and filtered by the signal processor so as to evaluate a signal strength associated with each said antenna coil, the processing system being arranged to evaluate a distance between a radio frequency transmitter and the radio frequency receiver on the basis of evaluated signal strengths associated with radio signals received by the at least one antenna coil;

wherein the radio frequency receiver is operable to receive and process radio signals of frequencies between 100kHz and 10MHz.

2. A radio frequency receiver according to claim 1, including three antenna coils, wherein the tunable receiver circuitry is selectively arranged to cooperate with each said antenna coil.

3. A radio frequency receiver according to claim 2, wherein each antenna coil is positioned along an axis in a direction extending substantially perpendicular to that occupied by the other antenna coils.

4. A radio frequency receiver according to claim 2 or claim 3, wherein, in a first operating condition, the receiver circuitry is arranged to select each of the three antenna coils in accordance with a specified selection procedure.

5. A radio frequency receiver according to claim 4, wherein the selection procedure comprises selecting each of the antenna coils sequentially.

6. A radio frequency receiver according to any one of claim 2 to claim 4, wherein the processing system is arranged to evaluate a distance between a radio frequency transmitter and the radio frequency receiver on the basis of evaluated signal strengths associated with radio signals received by each antenna coil.

7. A radio frequency receiver according to any one of claim 4 to claim 6, wherein the receiver circuitry is arranged to operate in a second operating condition wherein none of the antenna coils is selected and the signal processor is arranged to amplify and filter radio signals in the second operating condition.

8. A radio frequency receiver according to claim 7 dependent on claim 4 or claim 5, wherein the processing system is arranged to use the filtered and amplified signals corresponding to the second operating condition to modify the signal strengths evaluated in the first operating condition.

9. A radio frequency receiver according to claim 8, wherein the signal processor is arranged to identify, within a time period, a sequence of frequencies in the amplified and filtered radio signals.

10. A radio frequency receiver according to claim 9, wherein the signal processor is adapted to identify correlation between filtered radio signals in order to identify a sequence of frequencies in the received signals.

11. A radio frequency receiver according to any one of claim 8 to claim 10, wherein the signal processor is arranged to identify a modulation pattern within the received radio signals and to compare the identified modulation pattern with a specified modulation pattern.

12. Proximity detecting apparatus comprising a low radio frequency receiver according to any one of claim 1 to claim 11 and a low radio frequency transmitter arranged to transmit radio signals of frequencies less than 10 MHz, wherein the radio frequency receiver is arranged to receive and process signals from said radio frequency transmitter so as to generate data indicative of a distance between said radio frequency transmitter and radio frequency receiver.

13. Proximity detecting apparatus according to claim 12, including a further said radio frequency transmitter, wherein said receiver antenna coils are arranged to receive first signals from the radio frequency transmitter and second signals from said further radio frequency transmitter.

14. Proximity detecting apparatus according to claim 13, wherein the processing system is arranged to access a function operable to output data indicative of a position in response to input indicative of signal strength received by the antenna coils, the processing system being arranged to input first and second signals to said function and to combine output indicative of first and second positions corresponding thereto so as to identify a position of the radio frequency receiver.

15. Proximity detecting apparatus comprising first and second low radio frequency receivers according to any one of claim 1 to claim 12, and a low radio frequency transmitter arranged to transmit radio signals of frequencies less than 10 MHz, wherein each of said first and second radio frequency receivers is arranged to receive and process signals transmitted from said radio frequency transmitter and wherein the proximity detecting apparatus comprises means arranged to combine signals processed by said first and second radio frequency receivers so as to generate data indicative of a position of said radio frequency transmitter relative to said first and second radio frequency receivers.

16. A low frequency radio receiver for use in a proximity detecting

system, the radio frequency receiver comprising three antenna coils each being operable to receive radio frequency signals at frequencies less than 10 MHz; tunable receiver circuitry arranged in operative association with each coil and being arranged to modify the frequency at which signals are received by the radio frequency receiver; signal processing means arranged to amplify and filter signals received by the radio frequency receiver; and frequency sequence identifying means arranged to identify, within a time period, a sequence of frequencies in the amplified and filtered signals.

17. A low frequency radio receiver according to claim 16, wherein, in a first operating condition, the receiver circuitry is arranged to select each of the three antenna coils in accordance with a specified selection procedure.

18. A low frequency radio receiver according to claim 17, wherein the selection procedure comprises selecting each of the antenna coils sequentially.

19. A low frequency radio receiver according to any one of claim 16 to claim 18, wherein the frequency sequence identifying means is arranged to correlate the filtered signals associated with at least one antenna coil in order to identify said sequence of frequencies.

20. A low frequency radio receiver according to any one of claim 17 to claim 19, wherein, for each frequency in the sequence, the receiver circuitry is arranged to operate in a second operating condition wherein none of the antenna coils is selected and the signal processor is arranged to amplify and filter signals corresponding to the second operating condition.

21. A low frequency radio receiver according to claim 20, wherein the processing system is arranged to use the filtered and amplified signals corresponding to the second operating condition to modify the signal strengths corresponding to the first operating condition.

22. A low frequency radio receiver according to any one of claim 16 to claim 21, including a processing system arranged to process filtered signals corresponding to the three antenna coils in accordance with a predetermined location determining algorithm so as to identify the position of a source of said radio signals received by the radio frequency receiver.

23. A low frequency radio receiver according to any one of the preceding claims, wherein the processing system is integral with the radio frequency receiver.

24. A frequency radio transmitter for use in proximity detection apparatus, the radio frequency transmitter being operable to selectively transmit signals at a plurality of different frequencies, and comprising an antenna circuit having a variable impedance and a frequency bandwidth associated therewith, the frequency bandwidth defining a frequency band within which the radio frequency transmitter is operable to transmit signals, wherein the antenna circuit is operable to modify the impedance so as to modify the magnitude of said frequency bandwidth, and to transmit a radio frequency signal having a frequency within said modified frequency bandwidth.

25. A frequency radio transmitter according to claim 24, wherein the antenna circuit includes a coil comprising a plurality of windings and tapping means for connection to said windings so as to vary the magnitude of the frequency bandwidth of the antenna circuit.

26. A frequency radio transmitter according to claim 25, wherein the tapping means is arranged to connect to a set of the plurality of windings.

27. A frequency radio transmitter according to claim 26, wherein the antenna circuit comprises:

a transformer comprising a first coil having a first plurality of windings

and a second coil having a second plurality of windings; and

tapping means for connection to said second plurality of windings so as to vary the frequency bandwidth of the antenna circuit.

28. A radio frequency transmitter according to claim 27, wherein the tapping means is arranged to connect to a set of the second plurality of windings.

29. A radio frequency transmitter according to any one of claim 24 to claim 28, including a direct current power supply, wherein said set of said windings is connectable to the power supply via a return path.

30. A radio frequency transmitter according to claim 29, wherein the return path includes a current direction controlling device.

31. A radio frequency transmitter according to claim 29 or claim 30, wherein the power supply comprises a battery and switching means arranged, in response to receipt of current from the battery, to output an alternating current.

32. A radio frequency transmitter according to claim 31, including variable frequency generation means arranged in operative association with said switching means, wherein the frequency of the alternating current output from said switching means is variable in accordance with input received from the variable frequency generation means.

33. A radio frequency transmitter according to any one of claim 29 to claim 32, including a capacitor arranged in parallel with said power supply, wherein the return path is connectable to said capacitor so as to return current from said set of windings to the capacitor.

34. A radio frequency transmitter comprising an antenna circuit, wherein the antenna circuit comprises a capacitance (C), and a coil comprising a

plurality of windings having an inductance (L), the antenna circuit having a frequency bandwidth (δf) associated therewith and including tapping means for connection to the coil so as to create a first set of windings and a second set of windings, each set of windings having a number of turns, wherein the number of turns of the first set is related to the number of turns of the second set by a turns ratio (n), and the frequency bandwidth of the antenna circuit is at least $\delta f = \frac{1}{4\pi.n.\sqrt{LC}}$.

35. A radio frequency transmitter according to any one of claim 24 to claim 34, operable to selectively transmit signals at a plurality of different frequencies less than 10 MHz.